

The Royal Academy
of Engineering

Global Research Award

A new computational model for mitral valves

Hosted by New York University, USA

Professor Xiaoyu Luo

Department of Mathematics, University of Glasgow



Project Highlights

- The Global Research Award of £24,428 was awarded to support Dr. X.Y. Luo to visit New York University (NYU) to work on a dynamic computational model for mitral valve (MV). The host collaborators were Professor C. Peskin and Dr. B. Griffith at the Courant Institute of Mathematical Studies. This visit formed an essential part of a bigger project funded by The British Heart Foundation and The Royal Society.
- The aim of the project is to develop a powerful 3D computational tool to characterize the operational behaviour of the mitral valve under physiological conditions using adaptive immersed boundary methods (IBAMR: <http://www.cims.nyu.edu/~griffith/IBAMR>) initially developed by the NYU group. This was achieved as follows:



MV prosthesis used by the Glasgow group

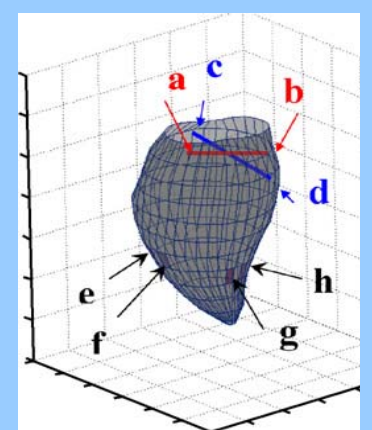


- Learnt, installed, and validated the C++ IBAMR package and its 3rd party libraries (Blitz, HDF5, PETSc, SAMRAI, hypre, Silo, VisIt).
- Developed a new interface between IBAMR and the three-dimensional mitral valve model, see figures on left.
- Gave 6 seminars, 3 conference talks and developed new collaborations.
- Obtained a new grant to support a visit of Dr. Griffith to Glasgow in 2008.
- Developed a new BHF proposal to apply this model to mitral valve repairs.

This project uses a designed MV model developed in the group, see figures above. The motion of the ventricle is treated as the time dependent boundary condition for the MV chordae during the cycle using high resolution MRI data from a normal human ventricle (Watton *et al.* v.24, 58-74, JFS, 2008), see figure below.

The project has led to following research papers (in which RAE is acknowledged):

- Luo X.Y., Cai Z. X., LI W.G., Pedley T. J., "The cascade structure of linear stabilities of flow in collapsible channels", *J. Fluid Mechanics*, Vol. 600, 45-76, 2008.
- Li ,W.G. Luo X.Y., Chin S.B., Hill N.A., Johnson A.G., & Bird N., Non-Newtonian Bile Flow in Elastic Cystic Duct•One and Three Dimensional Modelling, (*submitted to*) *Annals of Biomedical Engineering*.
- Liu H. F, Luo, X. Y. Cai Z. X. & Pedley T. J., Sensitivity of unsteady collapsible channel flows to modelling assumptions, (*submitted to*) *Communications in Numerical Methods in Engineering*
- Yin M., Luo X. Y., Watton P., Wang T. J., Vortex of the left ventricle motion and dynamic bioprosthetic mitral valve (*in preparation*)
- Luo X. Y., Griffith B.E., Flows in collapsible channel with adaptive immersed boundary method IBARM (*in preparation*)
- Luo X. Y., Griffith B.E., Dynamic simulation of a porcine mitral valve using an adaptive



Conclusion

The project was highly successful, and all aims and objectives have been fully achieved. It also led to a strong on-going research collaboration with the NYU group, as well as with several other groups. Further funding opportunities are being explored, and Dr. Luo would like to express her sincere gratitude to the Royal Academy of Engineering for the Global Research Award.

